

Stomotoca apicata, medusæ.
 Willia ornata, young medusæ; last of September.
 Dipurnea conica, medusæ; July; evening.
 Gemmaria gemmosa, medusæ; evening.
 Pennaria tiarella, medusæ; August, September.
 Ectopleura ochracea, medusæ; September.
 Nanomia cara, August, September; evening.
 Physalia Arethusa, July to September; day, (450.)
 Velella mutica, August; day.

Polyps.

Edwardsia, sp., larvæ in the "Arachnactis" stage; September; evening, (451.)

PROTOZOA.

Numerous kinds of ciliated infusoria, (451.)

List of species taken at the surface in winter, December to March.

Crustacea.

Crangon vulgaris, young.
 Mysis Americana.
 Anonyx, (?), sp.
 Calliopius læviusculus, (439.)
 Pontogeneia inermis.
 Gammarus natator.
 Monoculodes, sp.
 Several species and genera of Copepods, very abundant.
 Larvæ of Balanus, December 21, January 7 and 8.

Annelids, &c.

Nereis virens, adult males.
 Sagitta, sp., adult, abundant, (440.)
 Pontonema marinum, adult.
 Other Nematodes, undetermined.

Acalephs.

Pleurobrachia rhododactyla, young and adult, abundant, (450.)
 Mnemiopsis Leidy, adult, abundant, (450.)
 Cyanea arctica, young; March.
 Tima formosa, adult, (449.)

II. 10.—ANIMALS PARASITIC ON FISHES, ETC.

Large numbers of fishes were examined, both internally and externally, for parasites, and a large collection of such parasites was made. The in-

ternal parasites were collected mainly by Dr. Edward Palmer, and will be of great interest when carefully studied and described. As yet, nothing more than a casual examination of them has been made. These internal parasites were found in nearly all kinds of fishes, chiefly in the stomach and intestines, but also very frequently in the flesh, or among the abdominal viscera, or in the air-bladder, or even in the eyes, &c. The internal parasites were mostly worms, but these belong to four very distinct orders.

1st. The "round-worms," *Nematodes*.

These are related to the round-worms so frequent in the intestines of children, and also to the notorious *Trichina* of man and the hog. One or more species are found in the intestine and stomach of nearly every kind of fish, and frequently, also, in the liver, peritoneum, eyes, and various other organs. One species, two or three inches long, is very frequently found coiled up spirally in the flesh of the cod. Another large species is frequently found in the flesh of the tom-cod, or frost-fish. Although these are not dangerous to man, they are very disagreeable when found in fish intended for food.

A species belonging to this group is very frequently found in the body-cavity of one of our species of *Sagitta* (see page 440).

2d. The flat-worms or "flukes," *Trematodes*.

These are short, more or less broad, depressed worms, which are provided with one, two, or more suckers, for adhering firmly to the membranes. They pass through very remarkable transformations, as do most of the other parasitic worms. Species belonging to this group are common in the stomach, œsophagus, and intestine, and also encysted or in follicles in the mouth, liver, peritoneum, and various other parts of the body.

3d. The thorn-headed worms, *Acanthocephala*.

These have an elongated roundish body, with a proboscis at the anterior end, covered with hooks, or recurved spines. The proboscis and front end of the body can be withdrawn and thrust out at pleasure. Such worms are very common in the stomachs and intestines of fishes, and are, perhaps, the worst parasites that torment them. The young of these worms also occur quite frequently, encysted in the liver, peritoneum, throat, mouth, and other organs.

4th. The "tape-worms," or *Cestodes*.

These are long flat worms, divided into many distinct segments, and are very frequently found in the intestines of most fishes. There are numerous species of them, ranging in size from less than an inch to many feet in length.

Although parasitic worms are found in nearly all kinds of fishes, they are most frequent and in the greatest variety in the large and very voracious kinds, such as sharks, rays, the angler or goose-fish, salmon, blue fish, cod, haddock, &c.

Nor are other marine animals free from these internal parasites. Cer-

tain species have been found in crustacea, others in mollusks, &c. Mr. A. Agassiz has briefly described, but not named, a remarkable worm that he found very common in the jelly-fish, *Mnemiopsis Leidyi*, and the young of this or a different species was observed by me in the same Acaleph. It appeared to be a species of *Scolex*. It was pale purple, with light yellowish orange stripes. I have previously mentioned a round worm (*Ascaris?*) which frequently occurs in winter in one of our species of *Sagitta*.

Most of the species that, in the adult state, inhabit fishes, live while young, or in the larval stages, in smaller fishes, or in other animals, upon which the larger fishes feed, and from which they thus derive their parasites.

Besides the parasitic worms there are also many internal parasites that belong to the Protozoa.

The external parasites of fishes are also numerous. They are chiefly crustacea and leeches.

Among the Crustacea there are a few species of Amphipods that are parasitic. One of these, *Laphystius sturionis*, lives upon the gills of fishes and upon the surface of the body. It was found on the gills of the "goose-fish," (*Lophius*), in Vineyard Sound, and on the back of skates at Eastport. It is remarkable in having large claws developed on the third and fourth pairs of legs, those of the first and second being small. Its color is light red.

Certain Isopod crustacea, belonging to the genus *Livoneca* (Plate VI fig. 29) and allied genera, live in the mouths and on the gills of fishes, clinging firmly to the membrane of the roof of the mouth, or other parts, by means of their strong sharp claws. These are generally unsymmetrical in form. The species of the genus *Bopyrus* live on the gills, under the carapax of shrimp and other crustacea, producing large tumors. A species is common on species of *Hippolyte* in the Bay of Fundy; and a species has been found in this region. The genus *Cepon* is allied to the last, and our species occurs under the carapax of the "fiddler-crabs" in this region.

Among the Entomostraca the number of parasitic species is still greater, but most of these live on the external surface and gills of fishes, though some of them occur also in the mouth. The species of *Pandarus* and allied genera adhere firmly to the skin, and are provided with a proboscis. They are very common on sharks, but occur also on other fishes. A *Pandarus* (Plate VII, fig. 31) and *Nogagus Latreillii* (Plate VII, fig. 32) were both found on "Atwood's shark," the "man-eater" of this region, associated also with *Nogagus tenax*. The species of "*Nogagus*" are merely the males of other genera, for no one has yet determined both males and females of the various species. The young of one species, *Caligus rapax*, were found swimming free at the surface.

The species of *Argulus* and allied genera are less strictly parasitic, or rather they adhere less closely, and apparently leave the fishes at pleas-

ure and migrate from one to another. Three species belonging to this group were taken at the surface with the towing-nets. The Lernæans are remarkable creatures. The females are generally very curious in form and very much larger than the more active and less abnormal males, and they are very low in structure, the reproductive system being enormously developed at the expense of nearly all the other organs. They live upon the exterior and gills of fishes, with the head deeply buried in the flesh, and subsist by sucking the blood of their victims. The *Lernæonema radiatum* (Plate VII, fig. 30) is very common on the menhaden, and is also found on the alewives.

There are many kinds of parasitic leeches. One of the most remarkable is the *Branchiobdella Ravenelii*, (Plate XVIII, fig. 89.) This genus is peculiar in having broad, foliaceous, lobed or scalloped gills along the sides of the body. The large species figured was found several times on the large "sting-rays," several of them usually occurring together, on a large spot which had become sore and much inflamed by their repeated bites. It is a very active species.

The *Cystobranchus vividus* is a much smaller and quite slender leech, which has small, papilliform, whitish gills that alternately contract and expand along the sides of the body, each surrounded by a semicircular white spot. The colors are brownish or purplish, with three rows of small white spots on the back. This species is frequent on the common minnow, (*Fundulus pisculentus*), in autumn and winter, and lives both in brackish water and fresh water. With the last, on the minnows, is found another slender leech, destitute of gills; this is the *Ichthyobdella Funduli*. It has, like the last, four ocelli. The color is pale green with darker green and brown specks, often with whitish transverse bands anteriorly, and a white ring behind the head, at the constriction; sometimes there is a narrow pale dorsal line.

A long, slender, sub-cylindrical leech, the *Pontobdella rapax* V., (Plate XVIII, fig. 91,) is quite common on the upper side of the "summer-flounder," (*Chænopsetta ocellaris*.) It is a very active species, dark olive or brown in color, with a row of square or oblong whitish spots along each side; the suckers are pale greenish white. The young are reddish brown, without spots.

A species of *Pontobdella* was found adhering to *Mysis Americana*, near New Haven, May 5, in three instances, but whether this be its normal habit is uncertain.

The *Malacobdella obesa* V. (Plate XVIII, fig. 90) is a large, stout, yellowish white leech, often two inches long, which is quite common in the branchial cavity of the "long clam," (*Mya arenaria*.)

The *Malacobdella mercenaria* V. is another similar species, but smaller and more slender, which lives in the same way in the "round clam" (*Venus mercenaria*.)

The *Myzobdella lugubris* is a small leech, which lives on the "edible crab" (*Callinectes hastatus*), adhering to the soft membranes between the joints and at the base of the legs.

List of external parasites observed on fishes and other marine animals of Southern New England.

In the following list I have included all the determined species observed in these waters, whether living in the sounds, or in the outer waters, or in the brackish waters of the estuaries, for most of these parasitic species are capable of living in as diverse conditions as do the animals which they infest, and most of the fishes pass from time to time into each of the divisions named, though some, like the cod, are chiefly found in the colder outer waters, and even there only in winter.

The list is undoubtedly very incomplete for it is based chiefly on collections made during two seasons, and mainly in the summer months. In addition to the true parasites I have, for greater convenience, included in the list some that merely live on or with other animals, either for the sake of shelter, or to feed upon their excretions, or to share their food. Some of these would be properly classed as "commensals."

ARTICULATA.

Crustacea.

Pinnotheres ostreum, (p. 367,) in oysters.

P. maculatus, in *Mytilus edulis*.

Laphystius sturionis, on goose-fish and skate, (457.)

Hyperia, species, on jelly-fishes, (439.)

Nerocila munda, on file-fish.

Conilera concharum.

Livoneca ovalis, on blue-fish, (457.)

Cepon distortus, in branchial cavity of *Gelasimus*, (457.)

Ergasilus labraces, on striped-bass.

Argulus catostomi, on the sucker, (*Catostomus*.)

A. laticauda, (457.)

A. latus.

A. megalops.

A. alosæ, on "alewives."

Caligus curtus, on cod-fish.

C. rapax, on sting-ray, (*Trygon hastata*.)

Lepeophtheirus, sp., on sting-ray.

Lepeophtheirus, sp., on flounder, (*Chænopsetta ocellaris*.)

Echthrogalus coleoptratus, on mackerel-shark, (*Lamna punctata*.)

E. denticulatus, on Atwood's shark, (*Carcharodon Atwoodi*.)

Pandarus Cranchii, (?) on dusky shark, (*Platypodon obscurus*.)

Pandarus, sp., on Atwood's shark, (*Carcharodon Atwoodi*.)

Nogagus Latreillii, on Atwood's shark,* (457.)

N. tenax, on Atwood's shark, (457.)

Pandarus sinuatus, on the "dog-fish," (*Mustelus canis*.)

Cecrops Latreillii, on *Othagoriscus mola*.

Anthosoma crassum, on mackerel-shark.
Lernæa branchialis, on cod-fish.
Penella plumosa, on *Diodon pilosus* and *Rhombus*, sp.
Anchorella uncinata, on cod-fish.
Lernæonema radiatum, on menhaden, (458.)
Lernæonema, sp., on a species of *Carangus*.
Coronula diadema, on whales.

Leeches.

Branchiobdella Ravenelii, on sting-rays; August, September, (458.)
Cystobranchus vividus, on minnows; October to December 18, (458.)
Ichthyobdella Funduli, on minnows; with last, (458.)
Ichthyobdella, sp., dredged off New London, April.
Pontobdella rapax, on flounders, (458.)
Malacobdella obesa, in long clams, (458.)
M. mercenaria, in round clams, (458.)
Myzobdella lugubris, on the edible crab, (458.)
Bdelloura candida, on gills of *Limulus*.

MOLLUSCA.

Gastropods.

Stylifer Stimpsonii, on the green sea-urchin.
Eulima oleacea, on *Thyone Briareus*, (418.)

III.—FAUNA OF THE ESTUARIES, HARBORS, PONDS, AND MARSHES.

The region about Vineyard Sound and Buzzard's Bay, like that of the entire southern coast of New England and the coast farther south, is characterized by large numbers of ponds, lagoons, and estuaries, having a more or less interrupted communication with the sea. These are usually quite shallow, though often of great extent. The bottom is generally muddy, with occasional patches of sand, but at the surface usually consists largely of decaying vegetable and animal *débris* mixed with mud.

The "eel-grass" (*Zostera marina*) grows in the shallower waters in great quantities, sometimes in small scattered patches, at other times covering large areas. Some of these ponds and estuaries receive considerable, though variable, quantities of fresh water from streams flowing into them, while others receive but little, except the surface drainage of the land immediately around them; but in most of them the fresh water is in sufficient quantities to give a "brackish" character to the waters. Owing to the narrow and often shallow channels by which the ponds communicate with the open waters, the tide is usually irregular, and its rise and fall often much less than outside, so that the waters have little tidal motion. The shallowness of the water and the abun-

dant eel-grass also impede the motion caused by the wind, so that these bodies of water are comparatively quiet under ordinary circumstances. The same causes allow the water to become highly heated during the summer. It is evident that the heat and quietness of the waters are unfavorable for the rapid absorption of oxygen from the air, while by the rapid decay of the dead materials of the bottom large quantities of carbonic acid and other gases must be evolved, which would in some cases soon render the water fatal to all animal life, were it not for the presence of the eel-grass, *Ulva*, and other plants that flourish in such waters, which, while absorbing the excess of carbonic acid, also help to give the requisite amount of oxygen to the water. During storms the mud of the bottom is quickly disturbed, causing the escape of noxious gases, and rendering the water turbid, while the eel-grass is torn up in large quantities, thus adding to the decaying materials of the bottom and shores. Moreover, in case of rain-storms or spring-freshets, the sudden addition of large volumes of fresh water often causes great changes in the density and character of the water, sufficient to kill species not adapted to such varying and peculiar conditions.

We accordingly find that although animal life is usually very abundant, the number of species that habitually live and prosper in these impure and decidedly brackish waters is comparatively small. But such as do occur are usually found in great quantities, and are remarkable for their hardiness and ability to live under widely varying conditions. Many of them are strictly southern species, which do not extend much farther north; but there are some, like the long clam, muscle, &c., which extend even to the Arctic Ocean and the coasts of Europe.

Many of the estuaries and harbors, and some of the ponds, have a much freer communication with the sea, and then the water is less brackish and generally less impure in other respects, and the number of species of animals becomes much greater. In other cases the water is so little brackish that the fauna is nearly identical with that of the outer bays. A few of these species are almost restricted to the brackish waters, but by far the greater number are able to live in pure seawater, and are accordingly also found in the bays and sounds. There are various degrees of preference shown by the different species; some are very abundant in the brackish waters and very seldom found outside; some evidently prefer the estuaries but are also abundant in the sounds; some flourish equally well in both situations; many are common in the estuaries but much more abundant in the pure waters of the sounds; and a large number which are occasionally found in the brackish waters, especially where but little freshened, have their proper homes in the pure waters outside.

Most of our food-fishes frequent the ponds and estuaries, either for the sake of food or for the purpose of spawning, and many spend the earlier part of their lives entirely in such waters. It is apparent, therefore, that among the few species of invertebrate animals living in the brackish waters, there are some that are of great importance as food for

fishes. It is true that many of the larger fishes frequent the estuaries to prey upon smaller ones, some of which are extremely abundant in these waters. But the small fishes, like minnows, as well as the young of the larger ones, feed chiefly upon the small crustacea, worms, and shells that live in the waters that they inhabit. Therefore the entire value of the estuaries as feeding-grounds for the larger fishes depends directly upon those species of crustacea, &c., that naturally live in brackish water.

In discussing the fauna of the estuaries I have found it most convenient to group the species under the following divisions: 1. Those of sandy shores and bottoms. 2. Those of muddy shores and bottoms. 3. Those inhabiting oyster-beds. 4. Those inhabiting the eel-grass. 5. Those attached to rocks, piles of wharves, floating timber, buoys, &c.

The lists could be greatly extended by including all the species to be found near the mouths of estuaries, or in those harbors and ponds that are scarcely brackish, for in these localities the fauna is nearly identical with that of the bays and sounds, and the lists already given on previous pages will also apply very well to such places.

As a general rule only those species that are abundant, or at least frequent, in waters distinctly brackish, have been included in the lists.

III, 1.—ANIMALS INHABITING THE SANDY SHORES AND BOTTOMS OF BRACKISH WATERS.

Sandy shores and bottoms are generally less common and less extensive than muddy ones, and occur chiefly toward the mouths of estuaries, or on the more exposed borders of the larger ponds and harbors, where the wave-action is greatest.

When such bottoms are covered with eel-grass, as often happens, the animals are quite numerous, but when destitute of vegetation the species of animals are but few, and mostly of the kinds that burrow. But when there is a mixture of mud with the sand the variety is much greater.

Near high-water mark, colonies of the "sand-fiddler," *Gelasimus pugnator*, (p. 336,) often occur, as on the sandy beaches outside. In the same situations the beach-fleas, *Talorchestia longicornis* and *T. megalophthalma* (p. 336,) also occur, burrowing in the sand; while the *Orchestia agilis* SMITH is abundant under the vegetable *débris* at high-water mark.

Several species of salt-water insects also occur, burrowing in the sandy beaches at and below high-water mark. Among these are several beetles, which live in such situations, both in the larval and adult conditions. The *Bledius cordatus* is one of the most abundant of these. This is a small, dark-colored, "rover-beetle," with very short elytra. It makes small, perpendicular holes in the sand near high-water mark, throwing up a little mound of sand around the burrows. A larger species, *Bledius pallipennis*, occurs lower down, at about half-tide mark and makes similar burrows, but they are larger and deeper. This spe-

cies is yellowish brown in color. The larva of a fly belonging to the Muscidae, and growing to the length of three-quarters of an inch, occurs beneath the sand at low-water mark, and was also dredged off-shore in three or four fathoms of water.

In the shallow waters and on the flats the common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10,) is always to be found in abundance where the water is not too much freshened by the rivers. The prawn, *Palæmonetes vulgaris*, (p. 339, Plate II, fig. 9,) is also frequent on the sandy bottoms, though more abundant among the eel-grass, and this species extends far up the estuaries into the mouths of rivers, where the water is but little salt.

The most abundant Annelids are *Nereis virens*, (Plate XI, figs. 47-50,) *N. limbata*, (Plate XI, fig. 51,) *Rhynchobolus dibranchiatus*, (Plate X, figs 43, 44,) *R. Americanus*, (Plate X, figs. 45, 46,) and *Scolecolepis viridis* V., (p. 345,) all of which burrow in the sand at low-water mark in the same way as on the shores of the sounds.

Under vegetable *débris* and stones, at high-water mark, the *Halodrilus littoralis* (p. 324) and *Clitellio irroratus* (p. 324) occur in abundance. The *Lumbriculus tenuis* burrows among the roots of grass at high-water mark.

The most abundant Gastropod shells are *Ilyanassa obsoleta*, (Plate XXI, fig. 13,) *Tritia trivittata*, (Plate XXI, fig. 112,) *Bittium nigrum*, (Plate XXIV, fig. 154,) *Astyris lunata*, (Plate XXI, fig. 110,) which occur on the flats and on the bottom in shallow water, but all are more common among eel-grass. The *Melampus bidentatus* (Plate XXV, figs. 169, 169a) is very abundant among the grass and weeds at and just above high-water mark. It contributes largely to the food of the minnows and other small fishes, as well as to that of many aquatic birds. The *Crepidula convexa* (Plate XXIII, fig. 128) is frequent on the dead shells occupied by the small hermit-crab, *Eupagurus longicarpus*, (p. 313,) which is abundant, running over the bottom in shallow water.

The most abundant bivalves are the long clam, *Mya arenaria*, (Plate XXVI, fig. 179,) and *Macoma fusca*, (Plate XXX, fig. 222.) These both occur burrowing in the sand between tides, and both occur far up the estuaries, where the water is very brackish, but they are most abundant where there is a mixture of sand and mud. In the estuaries the long clam is extremely abundant all along the coast from New Jersey to the Arctic Ocean, as well as on all the northern coasts of Europe. It also occurs south of Cape Hatteras, as at Beaufort, North Carolina, but in greatly diminished numbers. North of New York it is very extensively used as an article of food. North of Cape Cod it is the common "clam" of the fishermen; and north of Boston it almost entirely displaces, in the markets, the "round-clam," or "quahog," *Venus mercenaria*, which is the common clam at New York and farther south. Along the southern coast of New England both species are abundant, and both are sold in large quantities in the markets. South of New

York the long clam is but little sought as an article of food, except for local use. On the coast of New Jersey it is often called the "maninose clam," from the Indian name (frequently corrupted to "nanny-nose.") It is also sometimes called the "soft-shelled clam," in distinction from the "quahog," which is called "hard-shelled." The "long clams" of certain localities on Long Island Sound, as, for instance, those from Guilford, Connecticut, are of very excellent quality, and are very highly esteemed.

The Guilford clams are assorted into regular sizes, and are bought from the fishermen on the spot by the hundred. Those of large size bring about \$3 per hundred; these are retailed in the market at New Haven for 60 cents per dozen. Smaller sizes bring 48 cents and 36 cents per dozen. During unusually low tides in winter clams of extraordinary size are obtained at Guilford, below the zone ordinarily uncovered by the tide; these often weigh a pound or more, and sell for about \$1.25 per dozen; occasionally the weight is as much as a pound and a half, and the shells become six or eight inches in length.

The ordinary long clams of small and moderate sizes bring 95 cents, \$1.25, and \$2 per bushel at wholesale; these retail in our markets at 50 cents to 75 cents per peck, the smallest sizes being cheapest, while the reverse is the case with the round clams.

In New Haven the long clams are chiefly sold in winter, being "out of season" in summer, when the round clams supply the markets. But in New York the long clams are sold during the whole year.

Large quantities of these clams are also collected on the northern coasts of New England and put up for bait, to be used in the cod-fishery at the banks of Newfoundland.

The total amount collected and used annually is probably not less than 1,000,000 bushels.

List of species inhabiting sandy shores and bottoms of estuaries.

ARTICULATA.

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III. 2.—ANIMALS INHABITING THE MUDDY SHORES AND BOTTOMS OF BRACKISH WATERS.

The bottoms of the sheltered estuaries, ponds, and harbors, are almost invariably muddy, throughout the greater part of their extent, from low-water mark to their greatest depths, or, in other words, wherever the waves do not act with considerable force. The shores between tides are also muddy in the more protected localities, where the waves do not have sufficient power to remove the fine sediments. The upper and narrower parts of nearly all the estuaries in this region are, on this account, muddy, for the rapidity of the tide is seldom sufficient to entirely remove the fine sediments brought down by the streams.

A large part of the muddy bottoms is generally covered in summer by extensive patches of eel-grass. Over other portions large beds of oys-

ters are always planted, thus greatly modifying the natural conditions of such localities and introducing a large number of species not properly belonging to the true muddy bottoms.

The shores of the muddy estuaries and ponds, or lagoons, are usually low, flat, and bordered by more or less extensive salt-marshes, with the surface generally just above high-water mark of ordinary tides, but liable to inundation by unusually high tides. These marshes are always traversed by winding and sluggish tidal streams of brackish water and by smaller ditches, and the surface is often diversified by small pools or ponds of impure brackish water, in which there is generally a deep deposit of soft, slimy mud and decaying organic matter, which often becomes putrid, and exhales fetid gases. All such waters, whether in the ditches or pools, and however filthy they may be, are inhabited by certain kinds of invertebrate animals, and they are also frequented by multitudes of minnows and other small fishes, which undoubtedly find abundant food in such places.

In these brackish pools and ditches we find certain beetles, both in the adult and larval stages. Among these the most conspicuous is *Hydrophilus quadristriatus* HORN., a large, black species, which appears to be common. The larva of the salt-marsh musquito (*Culex*, sp.) also lives in such situations, and the adults in August, September, and October, so swarm in these marshes as to render it extremely unpleasant to go on or near them. The larvæ of an *Ephydra* also occurs, and many other insects will doubtless be found in these places when carefully sought for.

One Amphipod, the *Gammarus mucronatus*, commonly lives in the most brackish pools and among the grass on the marshes. The prawn, *Palæmonetes vulgaris*, (Plate II, fig. 9,) is also very abundant in these pools and ditches, even where the water is but little salt, and also occurs in immense numbers on the muddy bottoms and among the eel-grass of the estuaries. In the pools there are also myriads of small Entomostraca of many kinds, upon which the prawn and other species feed, while the Entomostraca find an abundance of ciliated Infusoria and other microscopic animals for food.

We find several species of crabs burrowing in muddy banks along the shores of the estuaries, as well as along banks of the streams and ditches in the salt-marshes. The most abundant of these is the marsh fiddler-crab, *Gelasimus pugnax*, which is often so abundant that the banks are completely honey-combed and undermined by them. These holes are of various sizes up to about three-quarters of an inch in diameter, and descend more or less perpendicularly, often to the depth of two feet or more. Occasionally in summer these crabs will leave their holes and scatter over the surface of the marshes, which at such times seem to be perfectly alive with them, but when disturbed they will scamper away in every direction and speedily retreat to their holes, but occasionally, at least, they do not find their own, for sometimes the rightful owner will be seen forcibly ejecting several intruders. It is probable that at

such times of general retreat each one gets into the first hole that he can find. Associated with this "fiddler" another related crab, the *Sesarma reticulata*, is occasionally found in considerable numbers. This is a stout-looking, reddish brown crab, with a squarish carapax; its large claws are stout and nearly equal in both sexes, instead of being very unequal, as in the male "fiddlers." It lives in holes like the "fiddlers," but its holes are usually much larger, often an inch or an inch and a half in diameter. It is much less active than the "fiddlers," but can pinch very powerfully with its large claws, which are always promptly used when an opportunity occurs.

The *Carcinus granulatus* (p. 312) of large size may often be found concealed in the cavities under the banks undermined by the two preceding species, along the ditches and streams in the salt-marshes. On the marshes farther up the estuaries, and along the mouths of rivers and brooks, and extending up even to places where the water is quite fresh, another and much larger species of "fiddler-crab" occurs, often in abundance; this is the *Gelasimus minax*. It can be easily distinguished by its much larger size and by having a patch of red at the joints of the legs. Its habits have been carefully studied by Mr. T. M. Prudden of New Haven, but his interesting account of them has not yet been published. He has also investigated its anatomy. According to Mr. Prudden this species, like *G. pugilator*, (see p. 336,) is a vegetarian. He often saw it engaged in scraping up and eating a minute green alga plant, which covers the surface of the mud. The male uses its small claw exclusively in obtaining its food and conveying it to the mouth. The female uses either of her small ones indifferently. In enlarging its burrows Mr. Prudden observed that these crabs scraped off the mud from the inside of the burrow by means of the claws of the ambulatory legs, and having formed the mud into a pellet, pushed it up out of the hole by means of the elbow-like joint at the base of the great claw, when this is folded down. He also ascertained that this crab often constructs a regular oven-like arch of mud over the mouth of its burrow. This arch-way is horizontal, and large and long enough to contain the crab, who quietly sits in this curious door-way on the lookout for his enemies of all kinds.

This species can live out of water and without food for many days. It can also live in perfectly fresh water. One large male was kept in my laboratory in a glass jar containing nothing but a little siliceous sand, moistened with pure fresh water, for over six months. During this whole period he seemed to be constantly in motion, walking round and round the jar and trying to climb out. He was never observed to rest or appear tired, and after months of confinement and starvation was just as pugnacious as ever.

Although some of the colonies of this species live nearly or quite up to fresh water, others are found farther down on the marshes, where the water is quite brackish, and thus there is a middle ground where this

and *G. pugnax* occur together. This was found by Mr. Prudden to be the case, both on the marshes bordering West River and on those of Mill River near New Haven. They are abundant along both these streams. The holes made by this species are much larger than those of *G. pugnax*. Some of them are an inch and a half to two inches in diameter.

The "blue crab" or common edible crab, *Callinectes hastatus*, (p. 367,) frequents the brackish streams and estuaries, where it is often taken in large quantities for the markets. These are usually brought to market early in May, but the "soft-shelled" ones, which are more highly esteemed, are taken later. These soft-shelled individuals are merely those that have recently shed their old shells, while the new shell has not had time to harden. The period of shedding seems to be irregular and long continued, for soft-shelled crabs are taken nearly all summer. The young and half-grown specimens of this crab may often be found in considerable numbers hiding in the holes and hollows beneath the banks during the flood-tide. When disturbed, they swim away quietly into deeper water. These small crabs are devoured by many of the larger fishes. During flood-tide the large crabs swim up the streams like many fishes, and retreat again with the ebb. They feed largely on fishes, and often do much damage by eating fishes caught in set-nets, frequently making large holes in the nets at the same time.

The "mud-crabs," *Panopeus Sayi* (p. 312) and *P. depressus*, (Plate I, fig. 3,) are very common in all the muddy estuaries and harbors. *P. Harrisii* also occurs in similar places; it is far less common, and apparently usually lives higher up toward high-water mark, under stones, &c., but it has been found on the salt-marshes at the mouth of Charles River, according to Dr. A. A. Gould.

The *Orchestia palustris* SMITH, is found on the salt-marshes, where it occurs under drift-wood, vegetable *débris*, &c., extending its range nearly or quite up to fresh water, and at times living in places that are almost dry, above high-water mark.

The *Squilla empusa* (p. 369) burrows in muddy shores and bottoms at or below low-water mark.

The *Gebia affinis* (p. 368, Plate II, fig. 7) also lives in similar places in deep burrows, as described on a previous page.

The "horseshoe-crab," *Limulus Polyphemus* (p. 340,) is also a common inhabitant of muddy bottoms, in estuaries, where it grows to great size.

The most common Annelids are partly the same as those given above for the sandy shores. The *Nereis virens* is generally very abundant; the two species of *Rhynchobolus* are common; and also *Lumbriconereis opalina*, (Plate XIII, figs. 69, 70;) *Cirratulus grandis*, (Plate XV, figs. 80, 81;) *Polycirrus eximius*, (p. 320, Plate XVI, fig. 85;) *Chaetobranchus sanguineus*, (p. 320;) and several other less conspicuous species.

Among the Gastropods by far the most abundant species is the *Ilya-*

nassa obsoleta, (p. 354, Plate XXI, fig. 113,) which creeps over the flats and muddy bottoms in countless multitudes, sometimes almost covering the entire surface. When left by the tide, on the flats, especially in cold weather, they will creep into the small pools and depressions of the surface, where they often huddle together in great crowds, sometimes forming many layers, one above another. This is probably the most abundant shell, of any considerable size, on the coast of the United States. It occurs abundantly from the Gulf of Mexico to Massachusetts Bay. It is essentially a scavenger, and owing to its vast numbers its services in that line must be of great value. It occurs far up the estuaries, where the water is decidedly brackish, but flourishes equally well on the outer shores.

The *Littorinella minuta* (Plate XXIV, fig. 140) also occurs in vast numbers on the mud-flats, and in the pools and ditches of the salt-marshes, but it is a small and inconspicuous species. It is, however, not overlooked by the small fishes and various aquatic birds, for they feed largely upon it.

The *Melampus bidentatus* (Plate XXV, figs. 169, 169a) is also extremely abundant on the muddy salt-marshes, creeping over the general surface, or in the shallow pools and ditches, and among the grass, creeping up the stalks. In shallow water, where not too brackish, the *Bulla solitaria* (Plate XXV, fig. 161) is sometimes found in considerable numbers, creeping over soft, muddy bottoms. It is a favorite article of food with the flounders.

Among the Lamellibranchs, one of the most common species is the *Modiola plicatula*, (Plate XXXI, fig. 258,) which occurs everywhere on the muddy banks at and above high-water mark, and also over the salt-marshes, along the borders of ditches and streams, and wherever there is sufficient moisture, partially imbedding its shell in the mud or among the roots of grass, and anchoring itself by means of a stout byssus. The long clam, *Mya arenaria*, (p. 463) and the *Macoma fusca*, (Plate XXX, fig. 222) are almost everywhere abundant on the shores between tides.

The "round clam," *Venus mercenaria*, (p. 359, Plate XXVI, fig. 184,) occurs on the muddy bottoms in shallow water, often in great abundance, especially where the mud is somewhat firm, or where there is an admixture of sand, and the water is not very much freshened. This clam is usually taken in such places by means of long-handled tongs, and sometimes with the dredge. It is especially abundant in the estuaries and harbors opening into Long Island Sound. The quantity of this clam taken annually for food is enormous, but it is impossible, at present, to get reliable statistics, either for this or the long clam, for they are mostly taken and sold, a few bushels at a time, by individual fishermen, and the traffic is diffused along the whole coast, from Florida to Boston; but it is probable that more than 1,500,000 bushels are annually consumed.

In the New Haven markets the round clams retail at \$2 to \$3 per bushel for the small ones, and \$1 to \$2 per bushel for the large ones.

The common muscle, *Mytilus edulis*, (p. 307, Plate XXXI, fig. 234,) is also extremely abundant on the muddy bottoms, forming immense beds in many places. It is taken in vast quantities for fertilizing the land, but is seldom used as food on our coast, although it is used extensively in some parts of Europe.

The muddy bottoms of the estuaries, ponds, and harbors, especially when composed largely of organic matter in a living state, afford the best localities for "planting" oysters, and they are extensively utilized for this purpose. The oysters thus planted are mostly brought from farther south, but young "natives" are also transplanted on a large scale in some localities.

It is, however, very certain that the oysters did not originally grow on muddy bottoms, for the young cannot maintain themselves during early life unless attached to some solid substance.

Therefore, where large oyster-beds have been planted, the bottom should no longer be classed as "muddy," but rather as a "shelly bottom," for a large number of animals, in addition to those of true muddy bottoms, live among or attached to the oysters.

Along the peaty and clayey banks, especially where undermined by the waves, even nearly up to high-water mark, the *Petricola pholadiformis* (p. 372, Plate XXVI, fig. 199,) and *Pholas truncata*, (Plate XXVII, fig. 200,) are often found in their deep burrows in considerable numbers. The *Tagelus gibba* (Plate XXVI, fig. 181, and Plate XXX, fig. 217,) burrows at and below low-water mark on the muddy and argillaceous shores of the estuaries, as well as on the shores of the bays. On muddy bottoms, toward the outer parts of the estuaries and harbors, the *Mulinia lateralis* (Plate XXVI, fig. 184, B) often occurs in great abundance. And in similar places, even where the bottom consists largely of decaying vegetable matter, the *Tellina tenta* (Plate XXX, fig. 225) and *Solenomya velum* (Plate XXIX, fig. 210) are sometimes found in considerable numbers. The *Callista convexa* (Plate XXX, fig. 219) also occurs in similar places.

The Ascidians, Bryozoa, and Radiata are almost entirely wanting on the muddy shores and bottoms of estuaries, unless in localities where eel-grass or oyster-beds afford them suitable stations; but such localities will be discussed farther on.

List of species inhabiting the muddy shores and bottoms of brackish waters.

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III. 3.—ANIMALS INHABITING OYSTER-BEDS IN BRACKISH WATERS.

Although the oyster-beds are generally planted on bottoms that were originally muddy, when covered wholly or partially with living oysters or with dead oyster-shells, such bottoms may properly be regarded as "shelly bottoms" analogous to the natural shelly bottoms of the outer waters. The shells of the oysters afford suitable attachment for various shells, bryozoa, ascidians, hydroids, sponges, &c., which could not otherwise maintain their existence on muddy bottoms, while other kinds of animals, such as crabs, annelids, &c., find shelter beneath the shells or in their interstices. Some species have apparently been introduced from farther south with the oysters; among these are *Modiola hamatus* and *Panopeus Herbstii*, neither of which is positively known to be fully naturalized on our shores.

In planting the oysters they are more or less uniformly scattered over the bottom, from somewhat above low-water mark to the depth of ten or twelve feet. The oysters thus planted are brought mostly from the waters of Virginia and Maryland in spring. During the summer they usually increase greatly in size, and often become very fat and improve in flavor. They are taken up in the fall, for if left exposed to the freezing weather of our winters, at least all those in very shallow water would be killed. They often double in bulk during the summer. Besides the immense quantities of oysters thus brought from farther south to be "planted" in our waters, large quantities of young "natives" are also collected from the localities where they naturally breed, and are planted on muddy bottoms in the brackish waters, where they grow very rapidly, usually attaining a size suitable for the market in two or three years.

These "native oysters," although of the same species as those brought from the south, are more hardy, and will live through the winter if covered by a depth of water sufficient to prevent them from freezing. The young oysters that attach themselves to stones, ledges, &c., between tides, often in great abundance, nearly all perish by freezing during the winter. They mostly become an inch to an inch and a half in diameter during the first summer. The period of spawning lasts for some time,

but most of it seems to be done in May, June, and July. The young, after swimming about for a short time, attach themselves to any suitable hard object, such as rocks, shells, timber, brush, &c. On our coast very few attempts have been made to raise the young oysters by artificial means, because the young oysters, of a size suitable to plant, can generally be bought at a price less than the actual cost of raising them. The time will doubtless come, however, when this will no longer be the case, and then the methods so successfully employed on the coast of France may be resorted to with great advantage.

The young oysters must find some solid substance to which they can attach themselves, before losing their locomotive organs, otherwise they will fall to the bottom and perish in the mud. It is evident, therefore, that although the oysters planted on muddy bottoms of the right kind will grow most rapidly, owing to the great abundance of their microscopic food in the mud and turbid water; yet such localities are unfavorable for breeding-grounds, because the young, or "spat," will find no suitable objects to which they can attach themselves, unless, by chance, to the shells of the old oysters. Therefore, if it be desired to have the oysters in such localities produce the young ones necessary to maintain the bed permanently, it will be necessary to place hard objects on the bottom, to which they may adhere. Stones, broken bricks, &c., may be used for this purpose, but nothing is better than old oyster-shells, and they are generally cheaper than anything else.

On the coast of France bundles of twigs or fagots, prepared tiles, and other objects have been used to catch the young, and they are allowed to remain on such objects until they become large enough to be removed and planted elsewhere.

It is obvious that the best breeding-grounds are on hard bottoms, where there are large quantities of dead shells, pebbles, &c., to which the young will be sure to adhere. But such bottoms are not the best localities for the rapid growth and fattening of the oysters. Therefore it is always found profitable to transplant the young oysters, when large enough, from hard bottoms to the muddy bottoms of the estuaries, where their natural food most abounds.

All muddy bottoms are not equally adapted for this purpose. The great differences to be found in the muddy bottoms of various localities have already been mentioned on a previous page. (See p. 430.) Those bottoms that are composed mainly of tenacious clay are unsuitable, both because the oysters become imbedded too deeply in the clay, and because such mud contains but little organic matter. Those that consist of clay or sand mixed with decaying vegetable matter, and have a black, putrid layer just beneath the surface are also unsuitable and should be avoided. Those that consist of very deep, soft, pasty mud, though the mud itself may be of good quality, are apt to allow the oysters to sink too deeply beneath the surface and thus become smothered in the mud.

The most suitable localities are those sheltered places where there is a firm substratum of sand or gravel, overlaid with a few inches of soft,

flocculent mud, consisting largely of living microscopic animals and plants, Infusoria, Diatoms, &c. Such localities are to be found in most of our shallow estuaries, harbors, and brackish ponds, and on such grounds the oysters grow and become fat with surprising rapidity.

The character of such bottoms is very liable to be changed by storms, especially in winter, either by the removal of the organic mud to some other part of the bottom or shore, or by the washing in of silt or clay in quantities sufficient to cover the bottom and destroy the living organisms. Thus it happens that a locality may be an excellent oyster-ground one year and comparatively worthless the next, or a poor locality may in the next year become a good one. And on this account the great reputation that the oysters of a particular locality often acquire in a favorable year may not belong to them in subsequent years, for the quality of the oysters changes with the character of the food and bottom where they grow. I have already mentioned several of the more important enemies of the oysters on former pages. (See pp. 306, 326.) The star-fishes, which are among the most destructive of these, do not flourish in brackish waters, and this is, therefore, a great advantage.

The quantity of oysters taken from our waters is far greater than is generally supposed by those not familiar with this important business. The best statistics are necessarily very incomplete, but they are sufficient to show the almost incredible magnitude of this industry, which is, moreover, rapidly increasing as the facilities for transporting the oysters to all parts of the country, even to the Pacific coast, are multiplied.

According to the official report of Hunter Davidson, commissioner, upon the oyster-fisheries, &c., of Maryland, January, 1872,* the quantity of oysters taken in Maryland waters in the year 1869-'70 was 11,233,475 bushels, which, at an average value of 35 cents per bushel, would amount to \$4,031,716. To catch and convey these to market 8,070 men were employed on the water; 7,190,400 bushels were taken by 642 vessels (tonnage 14,436) engaged in dredging, and employing 4,060 hands. The balance, 2,043,075 bushels, were taken by 1,647 boats or "canoes," using tongs and rakes, and employing 3,410 hands.

In 1870-'71, 597 vessels, (tonnage 13,425,) engaged in dredging, and employing 3,775 hands, took 6,686,400 bushels; and 1,649 "canoes" took, with tongs, 2,261,403 bushels, employing 3,507 hands; making the total amount for the year, 10,947,803 bushels, valued at \$3,831,731. Many of these oysters were sold at \$1 to \$1.50 per bushel, while others were sold for less than twenty-five cents, but it is probable that the estimated average value (thirty-five cents) is considerably below the actual value.

The quantity taken in the waters of Virginia is probably quite as large as that from Maryland.

Large quantities are also taken along the coast of New Jersey, Long

* Report on the Oyster-Fisheries, Potomac River Shad and Herring Fisheries, and the Water-fowl of Maryland, to his excellency the governor and other commissioners of the State oyster-police force, January, 1872.